HYDROGEN-OXYGEN ELECTROLYTIC REGENERATIVE FUEL CELLS

Prepared for

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1. INTRODUCTION

This report reviews the progress made on development of a hydrogen-oxygen regenerative fuel cell, NAS Contract 3-2781, during the period November 7--December 6, 1964. During the period covered, a number of single cell tests were conducted, and a 6-cell 75-watt unit was also assembled and tested. Data for tests of these cells is presented in the report.

2. TECHNICAL DISCUSSION

2.1 Single Cell Tests

Table 1 summarizes the single cells subjected to test during this period. Cell No. 25 was subjected to a range of different current discharges at elevated temperature (125°C) to determine performance capabilities. Data for this cell was presented in the previous monthly progress report. Testing of this cell was discontinued in order to use the instrumentation with the 6-cell, 75 watt unit.

Cell No. 26 was assembled to demonstrate single cell performance to the NASA technical monitors of the program, who visited EOS during this period. This cell was cycled 2 times, and subjected to discharges at various currents from 10-91.5 amps, for short periods of time. The cell was then allowed to sit overnight at the elevated temperature, after which, the mat was removed, and the KOH concentration was analyzed. It was found to have dropped from 40 to 34 percent KOH. Considering the continual losses of KOH observed in cells thus far, it was decided that a special series of single cell tests will be conducted in the next period in order to establish a better understanding of the cause of the KOH deterioration.

Phase II of the program calls for a 500-watt unit with individual cells of 6-inch diameter having a capacity of 21 amp. hours. Previous work has been done with the 6-inch diameter cell of nominal 10 amp. hour capacity. In order to increase the capacity, it will be necessary to rearrange the mat composition compression, dry-weight, and electrolyte quantity in order to contain sufficient water to provide 21 amp. hours capacity. A series of cell tests was initiated to study mat variations in order to improve this capacity. Cell No. 27, the first in the series, consisted of a thicker mat with increased quantity of electrolyte above what has been previously used. In order to obtain the higher capacity

TABLE 1

Cell No.	O_2 Electrode No.	O_2 Electrode Cat.	H_2 Electrode No.	H_2 Electrode Cat.	Spacer	Mat Grade and Thickness	Mat Dry Wt.		Wt.	Remarks
25	46	20 Mg.Pt.	45	20 Mg.Pt.	.040	Pure 0.050	22	40.5	29	Stopped test to test new unit Final KOH
26	46	20 Mg.Pt.	45	20 Mg.Pt.	.040	Pure 0.050	22	40.5	21	Used to check KOH loss. Final KOH 34.
27	46	20 Mg.Pt.	45	20 Mg.Pt.	.045	Pure 0.055	24.0	40.5	31.5	Cell had thermo-chemical reaction on first discharge
28	46	20 Mg.Pt.	45	20 Mg.Pt.	.045	Pure 0.055	24.2	40.5	31.5	Cell improved Capacity See Fig. 1
29	46	20 Mg.Pt.	45	20 Mg.Pt.	.045	Pure 0.052	23	40.5	33	Cell improved capacity.

using the fixed volume single cell, the cell was charged to 500 psi. When the first discharge was started, a noise was heard in the cell, and a rapid pressure drop noted. The test was then stopped, the cell vented, disassembled and examined. The mat periphery looked as if it had been eaten away, and there was a black deposit in the gas compartments. (Note, the edges were not rubberized) It was decided that the mat had possibly been placed off center, and therefore cell No. 28 was assembled using the same mat arrangement.

The mat configuration of Cell No. 28 provided increased capacity, but did not provide the full 21 amp hours desired. Voltage rose high at the end of charge indicating the drying out of the mat. Therefore, initial discharge voltage was quite low, and at the end of discharge, voltage fell off rapidly. This performance is shown in Figure 1.

Cell No. 29 contained a mat with reduced compression and increased electrolyte. The cell was cycled at charge currents of 10 and 20 amps. and a discharge current of 20 amps. The cell charged well and discharged well except at the end of discharge when performance fell off rapidly, as shown in Figure 2. The data indicates poor Faradic efficiency also. To improve discharge performance and avoid the apparent flooding at the end of discharge, the cell was vented of 100 psi to reduce the water content at the end of the fourth cycle. At the start of the fifth cycle discharge, a noise was heard in the cell, and the pressure dropped rapidly, i.e., 200 psig. The test was stopped, the cell vented, disassembled and examined. Once again the edges of the mat were badly eaten away, and black deposits were found in the gas compartments. In these tests the mat compression had been reduced, and apparently the seal on the mat edges was not sufficient to prevent gas leakage. In future tests of this type, an edge sealant will be used to provide a better gas seal.

2.2 Multi-Cell 75-Watt Unit Testing

During this period, an additional 6-series cell unit was assembled and subjected to test. This unit was similar to construction to the unit described in monthly progress report number 13, with the

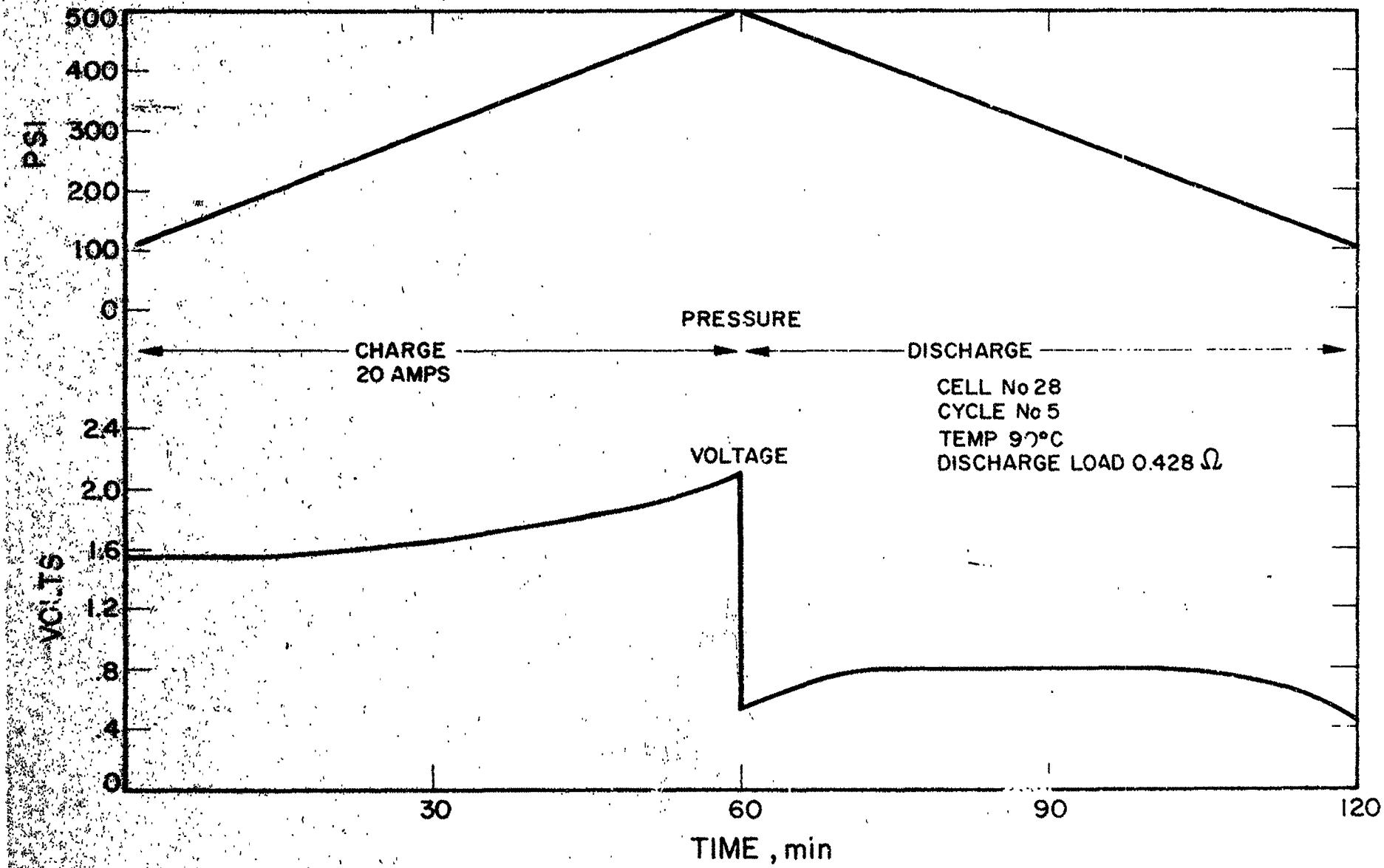

FIG. 1 H_2-O_2 REGENERATIVE FUEL CELL INCREASED CAPACITY TEST

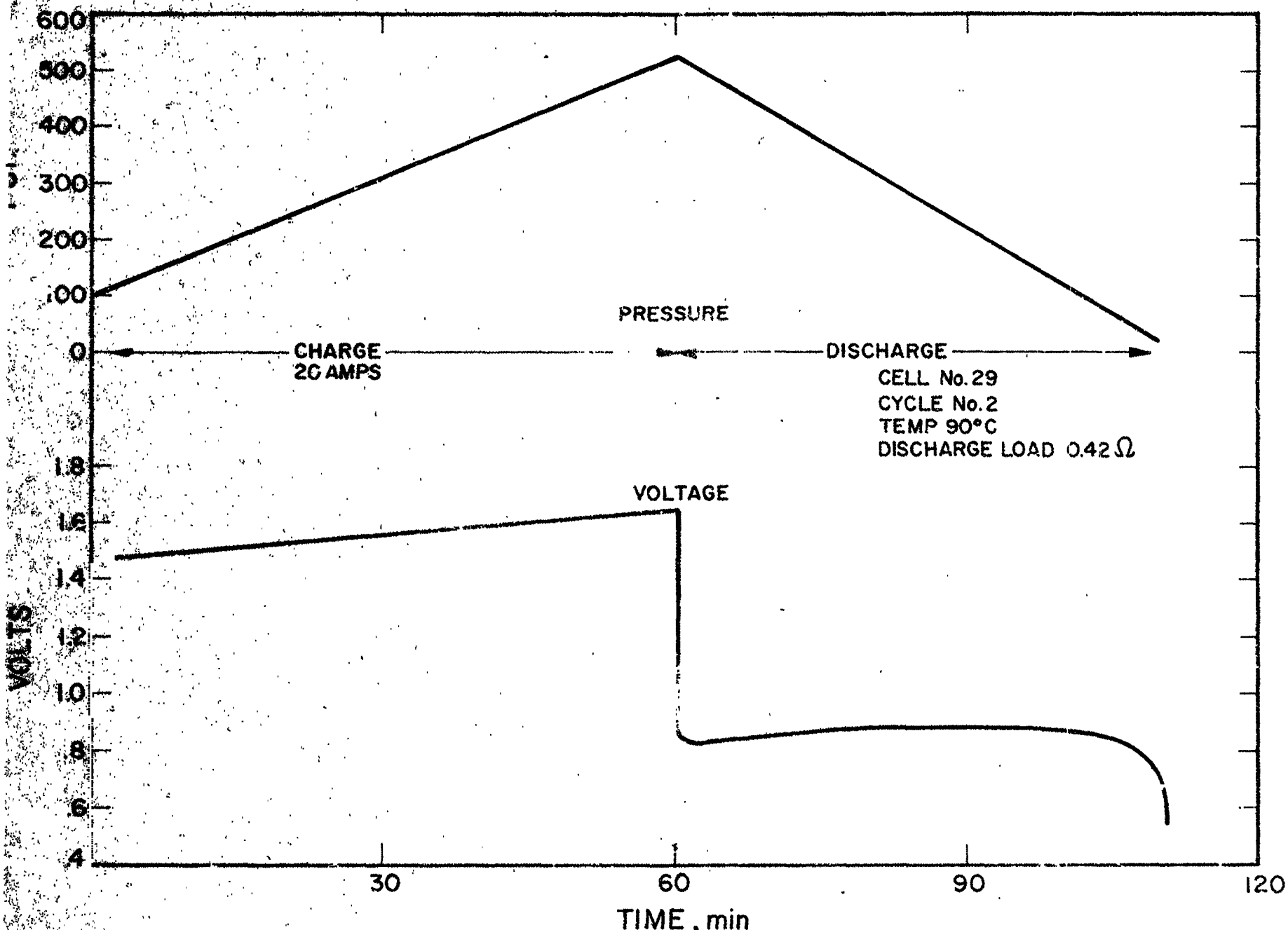

FIG. 2 H_2-O_2 REGENERATIVE FUEL CELL INCREASED CAPACITY TEST PRESSURE

exception that the oxygen electrodes consisted of a mixed catalyst, i.e., 10 mg. of platinum, and 10 mg. of palladium per sq. cm. In addition, insulating washers that were used on stack bolts were fabricated out of glass epoxy rather than the previously used nylon in order to prevent relaxing of the washers during load at elevated temperatures.

The unit was cycled in the normal manner, 55 minute discharge, 65 minute charge. During the first two cycles, the temperature was gradually raised, and the unit discharged at approximately 15 amps. at 5.2 volts. For the remaining 14 cycles, performance increased slightly, and the discharge current was set at approximately 18 amps. The unit was cycled only during the day. Overnight the unit was kept at elevated temperature. Prior to shut down, the unit was vented of all pressurized gas, and the following morning was repressurized to the original pressure level of the previous evening. Figure 3 shows a typical charge-discharge curve of the cell during the cycling period. On the morning following the 16th cycle, when the cell was being pressurized to be put into service it was noted that there was cross leakage between gas compartments, and the cell was not capable of holding a differential pressure. In addition, a slight rise in temperature was recorded internally in the cell (15^{o}-20^{o}) during this filling period. It was decided, that for some unknown reason, gas leakage was occurring, and possibly recombining on one of the electrod surfaces. The unit was therefore disassembled and examined.

Examination of the disassembled unit revealed that the stack bolts had relaxed considerably. These bolts were initially torqued to 75 inch/pounds. Inspection of the unit revealed that the bolts were essentially at 0 torque after the testing period. A relaxation of the bolts of this type most probably released the compression on the mats, and allowed gas leakage between cell compartments at the mat periphery. Considering this difficulty, it has been decided to utilize some form of loading springs on the stack bolts to eliminate the relaxation problem in the future. The mats had a grey discoloration adjacent to the hydrogen electrode, but otherwise were satisfactory, and they did not stick to the electrodes. There were no obvious indications of any gas recombination

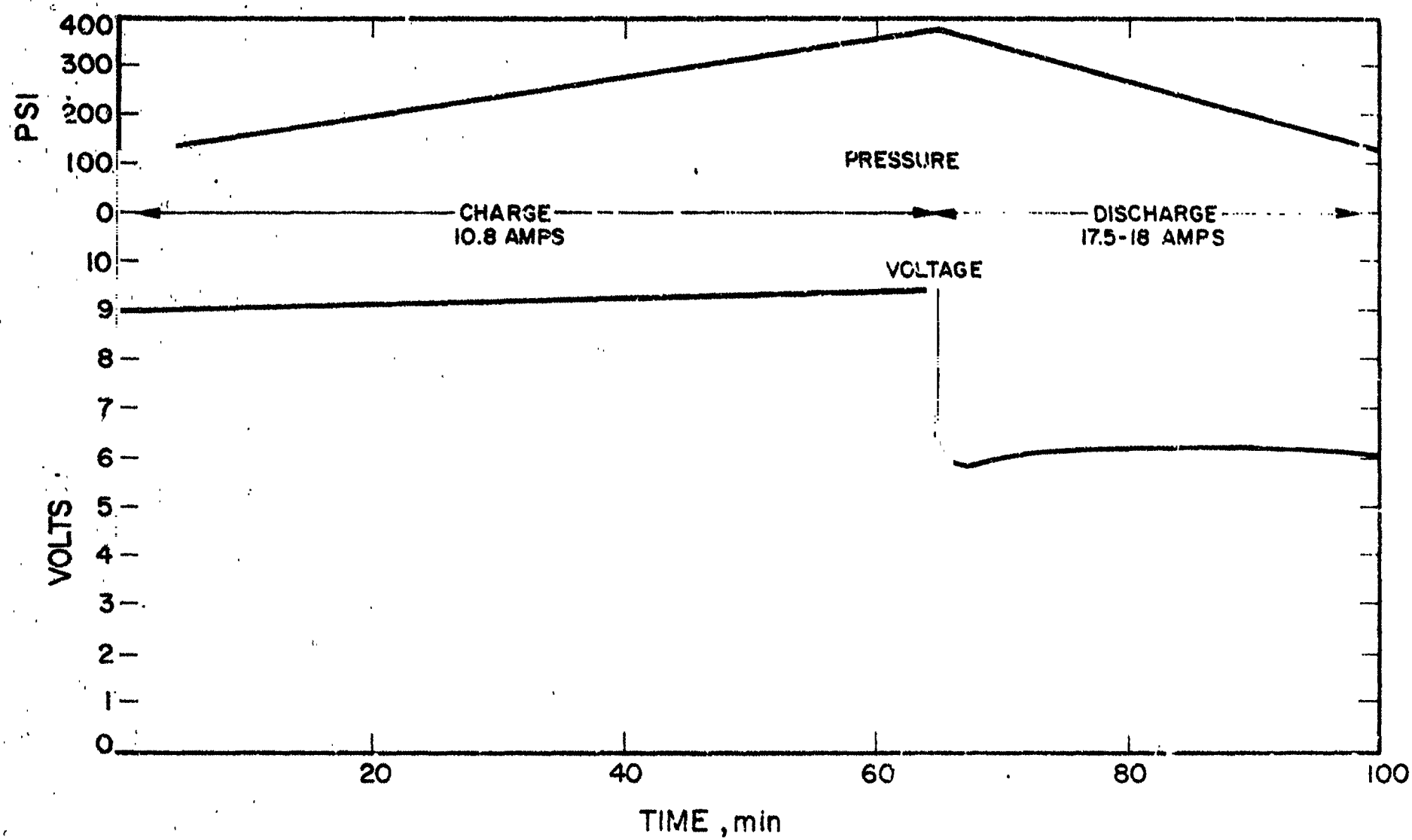

FIG. 3 H_2-O_2 REGENERATIVE FUEL CELL CYCLE PERFORMANCE OF SIX CELL UNIT S/N 102

within the entire assembly. It was noted, however, in a few places that the nickel plating of the magnesium separators had peeled away slightly. Analysis of electrolyte concentration, within two of the mats of the disassembled cell, revealed concentrations of 33 and 34 percent KOH.

2.3 Asbestos Studies

Preliminary tests of permeability of fuel cell asbestos were conducted. (The test arrangements for these tests are described in the tenth monthly report.) This asbestos, as compared to the other types previously tested, has a higher resistance to gas leakage. The 0.050 thick mat (22 gms.) containing 29 gms 40 percent KOH, which is the configuration used in the recent cell test, showed no leakage up to 20 psi.

3. PLANS FOR THE NEXT PERIOD

During the next period, a series of single cell tests will be run to establish a pattern, and obtain a better understanding of the cause for electrolyte deterioration and consumption during cycling.

In addition, single cell tests will be continued in an attempt to determine the right configuration for increased cell capacity. Another complete single cell and instrumentation will be fabricated and assembled to increase the rate of testing. Initial design work will be conducted on the 500-watt multi-cell unit.

In order to complete permeability data, additional tests will be conducted to evaluate the effect of thickness and number of mats on permeability.

4. FINANCIAL STATEMENT

Manhours and dollar expenditure for the period October 30 through December 4, 1964 were as follows:

Direct Labor Hours	330
Direct Labor Dollars	£2,637.02
Purchases and Commitments	1,527.65
Total Dollar Expenditure	£10,845.18